ELECTRICAL MACHINE II LABARATORY MANUAL

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VOLTAGE REGULATION OF AN ALTERNATOR BY ZPF METHOD

AIM OF THE EXPERIMENT:- To find out the voltage regulation of an alternator by ZPF method.

MACHINE SPECIFICATION: Alternator 3.5 KVA,1500rpm, 5 amp, 415V, 3-Φ. 50Hz excitation-

220V dc.

APPARATUS REQUIRED:

SL.NO	ITEM	TYPE	SPECIFICATION	QUANTITY
1	Rheostat	Double tube	(0-200Ω), 2A	2
2	Ammeter	MI	(0-10)A	1
3.	Ammeter	MC	(0-2)A	1
4.	Voltmeter	MI	(0-300)V	1
5.	Variable load	Inductive	440V, 10A	1
6.	Tachometer	Analog	(0-10000)rpm	1
7.	Connecting Wire	Flexible	$1.5mm^2$	As required

CIRCUIT DIAGRAM:-

THEORY:

As the load upon a synchronous generator increases, the terminal voltage decreases and the rate of decrease is expressed in terms of the voltage regulation.

Voltage regulation = [(E0-V) / V] ×100

From ZPF and No Load Characteristic, the potier triangle can be drawn and the no load voltage Eo can be calculated by neglecting laRa drop. Eo, the voltage regulation can be found out by using the above relation.

PROCEDURE:-

1. Connect as per the circuit diagram.
2. Ensure that the Rheostat1 if Rheostat2 are at zero position and TPST is open.
3. Start the D.C shunt motor by 3-point starter and adjust the rheostat 1 till rated speed of alternator.

4. Now vary the Rheostat 2 step wise of take down the readings of voltmeter corresponding to field current which gives the no load characteristics.
5. set the Rheostat 2 for a rated voltage and switch ON the TPST and adjust the load till rated current flows through ammeter.At that time, take down the reading of voltmeter and corresponding field current.
6. Now change the load to another value and adjust field current till again rated current flows and take the reading of voltmeter and corresponding field current.
7. Repeat again for anther load.
8. Now remove the variable Inductive load and short ckt. the armature terminal through ammeter,and
9. Vary the Rheostat2 slowly so that the rated current flows through ammeter and take down the ammeter reading when rated current is flowing through it.
10. Switch OFF the TPST and bring the Rheostat2 to zero position and machine can be switched OFF.

TABULATION:-

Sl.No.	No load Characteristics		Zero Power Factor Characteristics		
	Ir in Amp	V in Volt	Ir in Amp	V in Volt	Ir(rated) in Amp

CALCULATION:-
From Graph

PRECAUTION:-

- Avoid loose connection
- Wear Rubber of leather shoes
- Don't start the machine without the permission of concern teacher
- Don't touch any bare part of wire or panel.

CONCULATION:-

From th O.C.C. and ZPFC, the voltage regulation of the alternator was found out to the % and this value is nearly equal to the actual value.

V AND INVERTED V CURVE OF A SYNCHRONOUS MOTOR

AIM OF THE EXPERIMENT:- To draw the V and Inverted V curve of a synchronous motor.
MACHINE SPECIFICATION:- Synchronous motor -5 Hp, 1500 rpm, 415V, 7.5 amp, Excitation-230V
DC generator -3KW. 1500 rpm, 11 amp, 220V, Shunt field-220V.

Sl.No.	Item	Type	Specification	Quantity
1.	Ammeter	MC	(0-2)amp	1
2.	Ammeter	MI	(0-15)amp	1
3.	Voltmeter	MC	(0-300)V	1
4.	Rheostat	D Tube	200 Ohm, 2 amp	1
5.	Rheostat	D Tube	100 ohm, 4.5 amp	1
6.	3-Φ pf meter	Dynamo meter	3-Φ, 440 V, 5/10 amp	1
7.	Load box	Resistive	3KW, 230V	1
8.	Connecting wire	Flexible	$1.5mm^2$	As per required

CIRCUIT DIAGRAM:-

THEORY:-

From phasor diagram of synchronous motor, it is clear that at normal excitation the current drawn by the machine is minimum. Above and below normal excitation the line current and the power factor will also be change from unity and if a graph will be plotted between line current and field excitation then it will appear as a V shape and the graph between excitation and p.f. will appear as inverted V shape as shown in the figure.
PROCEDURE:

1. Connect as per the circuit diagram and ensure that the rheostat-1 at zero position and rheostat-2 is at maximum position.
2. Switch on the 3-ph AC supply.
3. Start the 3-ph synchronous motor by means of DOL starter and then vary the rheostat-2. So that the voltmeter will read the rated voltage of DC shunt generator.
4. Switch on the load such that the current of the Synchronous Motor can't exceed it's rated value.
5. At particular load value increase the field excitation of synchronous motor by rheostat-1 in a step manner.
6. In all step, note down the armature current and field current and pf of synchronous motor.

TABULATION:-

Sl.No.	If in Amp	I1 in Amp	PF

GRAPH:-

1. I1 v/s i1
2. p.f. vs I1

PRECAUTION:-

- Avoid loose connection
- Wear Rubber or leather shoes
- Don't start the machine without the permission of concern teacher.
- Don't touch any bare of wire or panel.

CONCLUSION:-

From the graph, it is clear that I1 and power factor changes, if If deviates from it's normal value and the curve looks like V and inverted V respectively.

SPEED CONTROL OF A 3-PHASE INDUCTION MOTOR BY ROTOR RHEOSTATIC METHOD

AIM OF THE EXPERIMENT:-To perform the speed control of a 3-phase Induction Motor by Rotor Rheostatic Method.

MACHINE SPECIFICATION:- Slip ring Induction motor

3-Φ , 5HP, 415V

50Hz, 1440rpm, 7.5A

APPARATUS REQUIRED:-

Sl.No.	Item	Type	Specification	Quantity
1	Rheostat	Double tube	(0-100)Ω, 4.5a	3
2	Tachometer	Analog type	(0-10000)rpm	1
3	Connecting Wire	Flexible	1.5 mm^2	As required

CIRCUIT DIAGRAM:-

THEORY:-

From the Torque-slip characteristic of 3-Φ I.M. , it is clear that during the operating period or stable period.

$T\alpha\ S.R_2$ ……1

$T\alpha\ 1/N$……...2

Where R2 = rotor resistance

T= Developed torque
N= Speed of Machine in rpm.

From equation (1) and (2) it is clear that
$R_2 \alpha$ 1/n ……3

Again the rotor resistance can be change in slip ring IM only. Hence this type of speed control can only be possible in case of slip ring IM only.
From equation(3) it is clear that by increasing rotor circuit resistance speed can be decreased but during this type of speed efficiency of the machine reduces because of external resistance.

PROCEDURE:-

1. Connect as per the circuit diagram and ensure that the rheostat is at zero position.
2. Switch on the supply by TPST and stat the I.M. by DOL starter at no load.
3. Note down the speed of I.M. by tachometer.
4. Switch off the I.M. by means of starter.
5. Adjust all the rheostat at 25%, 50% , 75% and corresponding speed must be recorded.

TABULATION:-

Sl.No.	External Rotor Resistance	Speed in RPM
1	0%	
	25%	
	50%	
	75%	

PRECAUTION:-

- Avoid loose connection
- Wear Rubber or leather shoes
- Don't start the machine without the permission of concern teacher.
- Don't touch any bare of wire or panel

CONCLUSION:-
From the experiment , it is clear that as inserted resistance increases the speed decreases.

MEASUREMENT OF PARAMETERS OF A SINGLE PHASE INCUCTION MOTOR

AIM OF THE EXPERIMENT:-To measure the parameter of a single phase induction motor.
MACHINE SPECIFICATION:- 1.5 HP, 230 V, 50Hz, 1-Φ capacitor start induction run type Induction Motor.

APPARATUS REQUIRED:-

Sl.No.	Items	Type	Specification	Quantity
1.	Rheostat	Double Tube	100Ω, 4.5A	1
2.	Variac	1-Φ	0-270V, 5A	1
3.	Voltmeter	MI	0-300V	1
4.	Voltmeter	MC	0-300V	1
5.	Ammeter	MI	0-5A	1
6.	Ammeter	MC	0-5A	1
7.	Connecting Wire	Flexible	1.5 sq mm	As required

CIRCUIT DIAGRAM:-

THEORY:-

- From Torque:- Slip characteristics of 1-Φ IM, it is clear that 1-Φ IM is not a self starting machine so to make it self starting the split phase method can be used.
- In this method , another winding is used called as starting winding, to create a flux in air gap with a phase difference to main flux. So that a torque can be produced during starting.
- From the phasor diagram, it is clear that the starting winding is more resistive and less inductive .
- And the capacitor C's function is to create a 'α' nearly equal to 90o because Tα sinα and the function of centrifugal switch is to disconnect starting winding after 80% of related speed of the machine.

The phasor diagram can be represented as

PROCEDURE:-

- Connect as per circuit diagram shown in fig(1) and ensure that the rheostat is at zero position.
- Give the supply by closing the DPST
- Vary the rheostat and take three different readings and find out the resistance of starting winding.
- Switch Off the supply and replace the starting winding by running winding.
- Repeat procedure(2) and (3) to find out the resistance of running winding.
- Now connect as per the circuit diagram(2) and ensure variac is at zero position.
- Switch ON the supply by DPST and vary the variac and take Ammeter reading at different value of voltage and find out the impedance.
- Repeat procedure(4)
- Repeat procedure(7) to find out the impedance of running winding.

TABULATION:-

1. Measurement of Resistance

Sl.No.	V in Volt	I in Amp	R in Ohm	R Mean in Ohm	V in Volt	I in Amp	R in Ohm	R mean in Ohm

2. Measurement of Impedance

Sl.No.	V in Volt	I in Amp	Z in Ohm	Z Mean in Ohm	V in Volt	I in Amp	Z in Ohm	Z mean in Ohm

CALCULATION:-
Starting Winding
Starting winding resistance =RsΩ
Starting winding Impedance=Zs Ω

$\Rightarrow$ Xs = $(Z^2s- R^2s)1/2$

$\Rightarrow$ Ls = Xs / $2\pi f$ in henry

PRECAUTION:-

- Avoid loose connection
- Wear Rubber or leather shoes
- Don't start the machine without the permission of concern teacher
- Don't touch any bare part of wire or panel.

CONCLUSION:-

From the experiment it was observed that starting winding is more resistive and less inductive than that of running winding.

SYNCHRONISATION OF TWO ALTERNATORS
AIM OF THE EXPERIMENT:- Synchronisation of two alternators by Dark Lamp method.
MACHINE SPECIFICATION:

1. Alternator :- 3KVA, 1500 rpm, 5A,415V, 3-phase , 50 Hz.
2. D.C. shunt motor :- 5 H.P. , 1500 rpm,17A,230V. Field shunt -230 DC.

APPRATUS REQUIRED:-

Sl.No.	ITEM	TYPE	SPECIFICATION	QUANTITY
1	Rhostat	Double Tube	0-200Ω,2A	2

2	Voltmeter	MI	0-600V	2
3	Tachometer	Analog	0-10000 rpm	1
4	Bulb		230V, 100W	6
5	Connecting Wire	Flexible	$1.5mm^2$	As per Required

CIRCUIT DIAGRAM:-

THEORY:-

When the demand load increases, it is better to connect and alternator in parallel with an existing one. This process of parallel operation is called as synchronization.

For synchronization of two alternators the following conditions must be satisfied.

1. The frequency of both alternators must be same.
2. The terminal voltage of both alternators should be same.
3. The phase sequence of both alternators should be same.

The conditions (1) and (2) can be verified by means of measuring instrument and the 3rd condition is verified by means of lamp method.

If two series Bulbs are connected across same phase of both alternator and the phase sequence is same both alternators (RYB) and (R'Y'B') then the voltage between same phases of both alternators will be zero and bulbs are dark. So as all bulbs are connected across same phases of both alternator s the 3rd condition will be satisfied when all the bulbs are dark.

PROCEDURE:-

1. Connect as per circuit diagram.
2. Ensure zero excitation to alternator 1 and 2.
3. Switch ON the DC supply and start the shunt motor of both alternators by means of three point starter.
4. By adjusting the Rheostat of field circuit adjust the speed of motor to rated speed of both alternators.
5. Now increase the excitation of both alternators till the voltmeters read the rated voltage of alternator.
6. Switch ON TPST-1 and TPST-2
7. If all the bulbs are dark at same time and bright at same time, then close TPST-3, when all bulbs are dark which completer the synchronization process.
8. Else switch OFF both the machines and interchange the consecutive phase connection of either alternator.
9. And the repeat from step(3) to step(7)

PRECAUTION:-

- Avoid loose connection
- Wear Rubber or leather shoes.

- Don't start the machine without the permission of concern teacher.
- Don't touch any bare part of wire or panel.

CONCLUSION:-
When the two alternators are in same phase sequence, then all the bulbs are dark and bright at same time but when phase sequence are different , the all bulbs are not dark and bright at same time.

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MEASUREMENT OF Xd AND Xq OF AN ALTERNATOR
AIM OF THE EXPERIMENT:- To measure the direct axis at quadrature axis reactance of an alternator.

MACHINE SPECIFICATION:-Alternator :-3.5KVA, 1500rpm, 5A, 415V, 3-phase, 50Hz excitation -220V D.C.
Shunt motors – 5Hp, 1500 rpm,220V, 17A. excitation -220V D.C.
APPARATUS REQUIRED:-

SL.NO.	ITEM	TYPE	SPECIFICATION	QUANTITY
1	Rheostat	Double tube	(0-200)Ω	1
2	Ammeter	M.I.	(0-10)A	1
3	Voltmeter	M.I.	(0-300)V	1
4	Variac	3-Φ	(0-440)V, 10A	1
5	Tachometer	Analog	(0-10000)rpm	1
6	Connecting wire	Flexible	$1.5mm^2$	As per required

THEORY:-THE Xd and Xq are the direct axis and quadrature axis reactance of synchronous machine at steady state and can be found out by slip test.
In slip test the alternator shaft be driven at a speed slightly less than the synchronous speed with it's field circuit open. 3-Φ balanced supply at rated frequency is applied to armature of synchronous machine and is also adjusted till rated current flows.
During this process the terminal voltage as well as the armature current will vary at q-axis the terminal voltage is minimum at armature current is maximum and at d-axis terminal voltage is maximum and armature current is minimum.
Xd = Vmax / Imin
Xq= Vmin / Imax
But if the alternator is a non salient type then the air gap is uniform.
Hence Xd= Xq.
PROCEDURE:-

1. Connect as per the circuit diagram.

2. Start the D.C. shunt motor by means of 3-point starter and adjust the speed of D.C. shunt motor by rheostat at 4% less speed than the rated speed of alternator.
3. Switch on the TPST and vary the variac till the armature draws the rated current.
4. At that time the voltmeter and ammeter pointer will oscillate. So during that oscillation the minimum and maximum value of oscillation of voltmeter and ammeter should be noted.
5. Reduce the variac to zero position and switch off the TPST and then stop the DC motor.

TABULATION:-

SL.NO	Vmin in Volt	Vmax in Volt	Imin in Amp	Imax in Amp
1				
2				
3				
4				
5				

CALCULATION:-

Xd= Vmax / Imin
Xq= Vmin / Imax

PRECAUTION:-

- Avoid loose connection
- Wear Rubber of leather shoes
- Don't start the machine without the permission of concern teacher.
- Don't touch any bare part of wire or panel.

CONCLUSION:-

As Xd and Xq are nearly the same they can be treated as equal. Hence from this, it is clear that the synchronous generator is a non-salient type.

NO LOAD AND BLOCKED ROTOR TEST OF 3-PHASE INDUCTION MOTOR

AIM OF THE EXPERIMENT:- To perform the No-load and Blocked rotor test of a 3-phase Induction Motor and to find out the efficiency by means of circle diagram.
MACHINE SPECIFICATION: Slip-ring 1M, 5HP, 3-phase, 415V, 7.5A, 50Hz, 1440RPM
APPARATUS REQUIRED:-

Sl.No.	ITEM	TYPE	SPECIFICATION	QUANTITY
1	Variac	3-phase	(0-440)V, 10A	1
2	Wattmeter	Dynamometer	10A, 600V	2
3	Voltmeter	MI	(0-600)V	1

4	Ammeter	MI	(0-10)A	1
5	Connecting Wire	Flexible	1.5mm^2	As required

CIRCUIT DIAGRAM:

THEORY:
From No-load Test,
$\tan\Phi_0 = \sqrt{3}\ [\ (W_{01} - W_{02}) / (W_{01} + W_{02})]$
or $\sqrt{3}\ V_0\ I_0\ \cos\Phi_0 = W_{01} + W_{02}$

From this equation the NO-load phase angle Φ_0 can be calculated
From Blocked Rotor Test
$\tan\Phi_{se} = \sqrt{3}\ [\ (W_{se1} - W_{se2}) / (W_{se1} + W_{se2})]$
or, $\sqrt{3}$ Vsc, Isc. $\cos\Phi_{se} = W_{se1} + W_{se2}$
from this equation Φse is the rated current at less applied voltage, Hence Ise (the S-C current at rated voltage) can be calculated as
Isc Isc
(Vrated / Vse).
So , by taking I_0 at angle of Φ_0 with respect to voltage V axis and Isc at an angle of Φ_{sc} with respect to the same voltage V axis the circle diagram can be drawn and then efficiency can be calculated.

SCOTT CONNECTION
AIM OF THE EXPERIMENT:- To obtain a balanced two phase supply from a 3-phase balance system.
MACHINE SPECIFICATION:- Transfromer 1-phase, 3KVA, 230 /115V, 50Hz.
APPARATUS REQUIRED:-

SL.NO	ITEM	TYPE	SPECIFICATION	QUANTITY
1	Voltmeter	MI	0-150V	2
2	Voltmeter	MI	0-300V	1
3	Variac	3-Φ	(0-440)V, 10A	1
4	Connecting Wire	Flexible	1.5mm^2	As required

CIRCUIT DIAGRAM:

THEORY:

We know that in 2-Φ balanced system, the two phase voltages are same in magnitude but in phase quadratuer as show in the figure

$Va_1a_2 = Vb_1b_2$

$Va_1a_2 = Vb_1b_2 \quad 90^o$
$\sqrt{(Va_1a_2^2 + Vb_1b_2^2)} = V\, b_2a_2$
As per the circuit diagram and vector diagram it is clear that $\sqrt{(V_1^2 + V_2^2)}$ must be equal to $\sqrt{3}$.

PROCEDURE:-

1. Connect as per the circuit diagram and ensure that the 3-phase variac is at zero position.
2. Switch on the three-phase supply by means of TPST and vary the variac.
3. Record the values of V_1 , V_2, V_3 at different position of variac,
4. Switch off the supply.

TABULATION:-

SLNO	V_1 IN VOLT	V_2 IN VOLT	$(V_1^2+V_2^2)$ ½ IN VOLT	V_3 IN VOLT	% ERROR
1					
2					
3					
4					
5					

PRECAUTION:-

- Avoid loose connection
- Wear Rubber or leather shoes
- Don't start the machine without the permission of concern teacher
- Don't touch any bare part of the wire or panel.

CONCLUSION:-

It has been found that, the error between $(V_1^2+V_2^2)$ ½ and V_3 is negligible and this error can be considered due to error in reading of the instruments.